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DEPARTMENT OF THE INTERIOR

UNITED STATES BUREAU OF MINES
JOHN W. FINCH, DIRECTOR

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COAL-MINE EXPLOSIONS AND COAL-AND METAL-MINE FIRES IN THE UNITED STATES DURING THE FISCAL YEAR ENDED JUNE 30, 1936

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BY

D. HARRINGTON AND W. J. FENE

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COAL-MINE EXPLOSIONS AND COAL- AND METAL-MINE FIRES IN THE UNITED STATES DURING THE FISCAL YEAR ENDED JUNE 30, 1936 1/

By D. Harrington 2/ and W. J. Fene 3/

INTRODUCTION

The record of fatalities from mine explosions in the United States during the past 3 years has been the best in the history of the mining industry. During these 3 fiscal years, mine explosions have resulted in an average of 40 deaths per year, as compared with an average of 153 deaths per year for the preceding 5 years; an average of 542 deaths per year for the 3-year period 1907-09, inclusive, just before the organization of the U. S. Bureau of Mines; and a yearly average of 265 deaths per year for the 20-year period prior to 1929. This remarkable reduction in deaths from mine explosions demonstrates clearly that mine explosions can be controlled; in fact, they can be prevented when or if the mining people of the United States see fit to take the readily available precautions necessary to bring about this desirable objective.

Several large coal-producing States, which in the past have had numerous disastrous explosions, have been free from such disasters for continuous periods of as much as 6 years or even longer. The bituminous mines of Pennsylvania, the largest coal-producing State, give a good example of what can be done to prevent explosions; this State has had only one major explosion (and it resulted in 7 fatalities) during the past 6 years, and no explosion occurred in the several hundred bituminous-coal mines of the State during the past fiscal year. This is a truly remarkable record when compared with past performance in any year in the operation of coal mines in Pennsylvania.

The factors mainly responsible for mine explosions are inadequate or defective ventilation and disregard of the hazards of explosive gas; hence, if ventilation is adequate and is properly controlled and maintained, the number of explosions will be negligible. This does not mean that coal dust can be ignored as a hazard in either well-ventilated or poorly ventilated mines, as coal dust can be ignited even when no methane is present regardless of the effectiveness or noneffectiveness of ventilation.

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2/ Chief, Health and Safety Branch, U. S. Bureau of Mines, Washington, D.C.

3/ Mining engineer, Safety Division, U. S. Bureau of Mines, Pittsburgh, Pa.

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TABLE 1. - Summary of explosions by States and causes - fiscal year 1936

State	Lighting system			Fatalities by ignition causes									
	Open	Closed	Unknown	Electricity		Open lights or smoking		Explosives		Miscellaneous or unknown		Total	
				Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions
Alabama.....	1	-	-	-	-	0	1	-	-	-	-	0	1
Colorado.....	-	2	-	8	1	-	-	4	1	-	-	12	2
Indiana.....	3	-	-	0	1	2	2	-	-	-	-	2	3
Kentucky.....	-	1	-	9	1	-	-	-	-	-	-	9	1
Ohio.....	1	-	-	-	-	4	1	-	-	-	-	4	1
Pennsylvania1/.	5	4	1	-	-	4	8	-	-	4	2	8	1/10
Washington.....	4	-	-	-	-	0	4	-	-	-	-	0	4
West Virginia..	1	2	-	3	2	0	1	-	-	-	-	3	3
Total, fiscal year 1936	15	9	1	20	5	10	17	4	1	4	2	38	25
Total, fiscal year 1935	6	17	-	29	10	6	9	3	2	16	2	54	23
Total, fiscal year 1934	9	14	3	21	10	2	9	2	3	3	4	28	26
Total, fiscal year 1933	7	14	1	25	8	63	8	29	4	5	2	122	22
Total, fiscal year 1932	15	15	4	11	10	33	15	42	5	1	3	87	33
Total, fiscal year 1931	12	15	-	143	9	56	11	18	6	-	-	217	26
Total, fiscal year 1930	8	25	1	154	18	21	8	24	6	-	2	199	34
Total, fiscal year 1929	18	19	1	93	18	14	11	26	8	6	1	139	38

1/ All of these 10 explosions occurred in anthracite mines. No explosions are known to have occurred in Pennsylvania bituminous mines in the fiscal year ended June 30, 1936.

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SUMMARY OF MINE EXPLOSIONS BY STATES

Table 1 summarizes 25 explosions that occurred in 8 States, with a total of 38 deaths, during the fiscal year ended June 30, 1936. This table gives data on all explosions in mines in the United States that were brought to the attention of the Safety Division of the U. S. Bureau of Mines during the fiscal year. It is believed to include every explosion in which life was lost or a great amount of damage resulted. Twenty-five explosions occurred during the year or 2 more than in the previous fiscal year; however, the number of deaths (38) was 16 less than in the previous year.

The States with the greatest number of deaths from explosions in the past fiscal year were Colorado, 12; Kentucky, 9; Pennsylvania, 8 (all in anthracite mines); Ohio, 4; West Virginia, 3; and Indiana, 2. The greatest number of explosions were in Pennsylvania, 10 (all in anthracite mines); Washington was next with 4 explosions; Indiana and West Virginia had 3 each; Colorado had 2; and Alabama, Kentucky, and Ohio had 1 explosion each.

Two major explosions occurred during the fiscal year 1936 which resulted in 17 deaths (a major explosion is one in which 5 or more lives are lost); during the fiscal year 1935 there were two major explosions and 13 deaths. Of the 25 explosions that occurred during the year, 13 did not result in any fatalities.

Twenty persons were killed during the past fiscal year in explosions caused by electricity, compared with an average of 25 deaths per year for the preceding 3 years and of 62 for the past 8 years, indicating a steady decrease in deaths from explosions of electrical origin. There were 5 electrical ignitions during 1936 compared with 10 such ignitions the previous year and an average of 11 for the past 8 years.

The greatest number of electrical ignitions, 2, occurred in West Virginia and resulted in 3 fatalities; Colorado, Indiana, and Kentucky had 1 electrical ignition each, with a total of 17 deaths.

In 1936, 17 ignitions were caused by open lights or smoking (of which 9 were in anthracite mines) compared with 9 during 1935 and an average of 10.1 during the previous 7 fiscal years. Deaths due to explosions caused by open lights or smoking last year numbered 10 compared with an average of 27.7 during the previous 7 fiscal years. Ignitions caused by open lights or smoking were distributed as follows: Pennsylvania 8, with 4 deaths; Washington 4, with no deaths; Indiana 2, with 2 deaths; Alabama and West Virginia, 1 each, with no deaths; and Ohio 1, with 4 deaths. Fewer deaths have resulted from explosions caused by open lights and smoking during the past 3 years than in any other 3-year period in the history of mining in the United States; however, the great increase in the number of ignitions caused by open lights and smoking (17 in the past fiscal year as against an average of 10 during the previous 7 years) is extremely disquieting and since some of this increase is due to smoking it is evident that discipline is lacking.

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TABLE 2. - Record of explosions by States during last 8 fiscal years

State	1928-29		1929-30		1930-31		1931-32		1932-33		1933-34		1934-35		1935-36		Total, 8 years		Average per year		Average deaths per ignition
	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	
Alabama	13	7	8	4	-	2	4	5	-	-	2	2	-	1	-	1	27	22	3.37	2.75	1.23
California	-	1	7	2	12	1	-	1	-	1	-	-	-	-	-	-	19	6	2.37	.75	3.17
Colorado	-	-	-	1	-	-	4	3	1	1	-	-	-	-	12	2	17	7	2.12	.87	2.43
Illinois	-	3	10	2	2	1	3	3	54	1	-	-	-	-	-	-	69	10	8.62	1.25	6.90
Indiana	-	-	-	-	28	1	-	-	4	2	-	-	-	-	2	3	34	6	4.25	.75	5.67
Kansas	2	1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	1	.25	.12	2.00
Kentucky	11	3	16	1	-	-	3	1	26	2	-	1	1	1	9	1	66	10	8.25	1.25	6.60
Maryland	-	-	-	-	-	-	1	1	-	-	-	-	-	-	-	-	1	1	.12	.12	1.00
New Mexico	-	-	-	-	8	3	-	-	14	1	-	-	-	-	-	-	22	4	2.75	.50	5.50
Ohio	3	3	1	2	88	3	-	-	-	-	-	-	-	-	4	1	96	9	12.00	1.12	10.67
Oklahoma	1	1	71	4	45	2	-	-	3	2	-	-	3	2	-	-	123	11	15.37	1.37	11.18
Pennsylvania	70	9	16	8	23	7	7	6	9	6	16	14	24	11	8	10	173	71	21.62	8.87	2.44
Tennessee	-	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-	-	3	—	.37	—
Utah	1	2	30	3	-	-	-	-	-	-	-	-	-	-	-	-	31	5	3.87	.62	6.20
Virginia	2	1	-	-	-	-	54	3	-	-	2	3	18	2	-	-	76	9	9.50	1.12	8.44
Washington	-	-	17	2	-	2	-	-	2	1	-	2	-	-	0	4	19	11	2.37	1.37	1.73
West Virginia	36	7	23	5	11	4	11	7	9	5	8	4	5	4	3	3	106	39	13.25	4.87	2.72
Wisconsin	-	-	-	-	-	-	-	-	-	-	-	-	-	1	-	-	-	1	—	.12	—
Wyoming	-	-	-	-	-	-	-	-	-	-	-	-	3	1	-	-	3	1	.37	.12	3.00
Total	139	38	199	34	217	26	87	33	122	22	28	26	54	23	38	25	884	227	110.50	28.37	3.89

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TABLE 3. - Comparison of explosions - ignition causes - fiscal years 1929 - 36, inclusive

Years	Ignition by electricity		Ignition by open lights or smoking		Ignition by explosives		Ignition due to unknown or miscellaneous causes		Total	
	Number	Percent	Number	Percent	Number	Percent	Number	Percent	Number	Percent
1928-29	18	47.4	11	29.0	8	21.0	1	2.6	38	100
1929-30	18	52.9	8	23.5	6	17.6	2	6.0	34	100
1930-31	9	34.6	11	42.3	6	23.1	-	.0	26	100
1931-32	10	30.3	15	45.5	5	15.1	3	9.1	33	100
1932-33	8	36.4	8	36.4	4	18.1	2	9.1	22	100
1933-34	10	38.5	9	34.6	3	11.5	4	15.4	26	100
1934-35	10	43.5	9	39.1	2	8.7	2	8.7	23	100
1935-36	5	20.0	17	68.0	1	4.0	2	8.0	25	100
Total, 8 years	88	38.8	88	38.8	35	15.4	16	7.0	227	100
Average per year	11.0	38.8	11.0	38.8	4.3	15.4	2.0	7.0	28.3	100

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There was only 1 explosion, with 4 deaths, during the past fiscal year caused by explosives, compared with an average of 4.9 explosions and 20.6 deaths during the previous 7 fiscal years; this is a new low record and is believed to be due to wider use of permissible explosives as well as to the extension of education in safe practices in the use of explosives.

Two explosions from miscellaneous or unknown causes resulted in 4 deaths in 2 Pennsylvania anthracite mines.

RECORD OF EXPLOSIONS BY STATES

Table 2 shows the record of explosions, by States, during the past 8 fiscal years. During the 8-year period, 227 ignitions caused 884 deaths, an average of 28.37 ignitions and 110.50 deaths per year. The number of ignitions and deaths during the past year was much less than the average for the 8 years; 3 fewer ignitions and 72 fewer deaths were caused by explosions last year than the average for the 8-year period. For this period, Pennsylvania heads the list in total number of known ignitions (71) and has the largest number of deaths (173); Oklahoma, with only 11 ignitions, had the next greatest number of deaths (123), with no known ignitions during 3 years of this period. It is of interest to note that during these 8 years Kansas, Maryland, Wisconsin, and Wyoming had 1 known ignition each, with a total of 6 deaths; that Tennessee had 3 ignitions without a fatality; and that Kansas has had no known ignitions for the past 7 years and Utah for the past 6 years.

The average number of deaths per ignition during the past 8 fiscal years is 3.89, with a range for the various States from none to 11.18 deaths per ignition. States with the most deaths per ignition during the past 8 years are Oklahoma (11.18), Ohio (10.67), and Virginia (8.44), in all of which relatively little attention is given to rock-dusting. No deaths resulted from 13 of the 25 explosions that occurred during the past year. The following coal-mining States and Territories are not listed in table 2 as having had an explosion during the past 8 fiscal years: Alaska, Arkansas, Iowa, Michigan, Missouri, Montana, North Dakota, and Texas.

CAUSES OF EXPLOSIONS

Table 3 gives data on causes of explosions in the United States during the past 8 fiscal years, as reported to the Safety Division of the Bureau of Mines. In all, 227 explosions have been studied during the 8-year period, an average of 28.3 explosions per year. There were 25 explosions during the past fiscal year—2 more than during the previous year and 3.3 less than the average for the 8 years. Electricity and open lights or smoking each accounted for 88 (38.8 percent) or a combined total of 77.6 percent of the explosions during this period.

The number of explosions of electrical origin during the past year (5) is a decrease of about 58 percent compared with the average of the preceding 7 years, while the number caused by open lights or smoking (17) has increased about 67 percent on a similar basis of comparison.

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TABLE 4. - Comparison of explosion fatalities by ignition causes in fiscal years 1929 - 36, inclusive

Years	Electricity		Open lights or smoking		Explosives		Unknown or miscellaneous cause		Total	
	Number killed	Percent	Number killed	Percent	Number killed	Percent	Number killed	Percent	Number killed	Percent
1928-29	93	66.9	14	10.1	26	18.7	6	4.3	139	100
1929-30	154	77.4	21	10.5	24	12.1	-	-	199	100
1930-31	143	65.9	56	25.8	18	8.3	-	-	217	100
1931-32	11	12.7	33	37.9	42	48.3	1	1.1	87	100
1932-33	25	20.5	63	51.6	29	23.8	5	4.1	122	100
1933-34	21	75.0	2	7.1	2	7.1	3	10.8	28	100
1934-35	29	53.7	6	11.1	3	5.6	16	29.6	54	100
1935-36	20	52.6	10	26.3	4	10.55	4	10.55	38	100
Total, 8 Years	496	56.1	205	23.2	148	16.7	35	4.0	884	100
Average, per year	62.0	56.1	25.6	23.2	18.5	16.7	4.4	4.0	110.5	100

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Table 3 shows that the number of explosions caused by explosives has decreased gradually during the past 8 years; only 1 such explosion occurred during the past fiscal year. No doubt there have been numerous explosions caused by explosives during the past 8 years besides the 35 listed, as many explosions originating from blasting which do not result in death or serious property damage may not come to the attention of the Safety Division personnel. The favorable reduction in explosions caused by explosives may be attributed chiefly to increased use of permissible explosives, to safer practices in the handling of explosives, and to improved ventilation.

Of the 2 explosions listed under unknown or miscellaneous causes, 1 may have been caused by the ignition of gas by a spark from a fall of rock, although this is both problematical and debatable; the other explosion under this classification was the result of misuse of a flame safety lamp.

EXPLOSION FATALITIES BY CAUSES

Table 4 compares explosion fatalities by causes and shows that during the past 8 fiscal years 884 fatalities have resulted from explosions in mines of the United States, an average of 110.5 per year. The record for the past 3 years, an average of 40 deaths per year, is by far the best since records have been available. The reduction in fatalities from explosions during the past 3 years has not been brought about through a marked decrease in the frequency of explosions but by a decrease in their severity. The average number of deaths per explosion during the first 5 years of this 8-year period amounted to 5.0, while the average number during the last 3 years has been 1.6. This reduction in the severity of explosions has been brought about, at least in part, by the use of rock dust to prevent widespread explosions and the use of water on cutter bars of mining machines to prevent the coal dust from getting into suspension in the air.

Explosions of electrical origin were responsible for 56.1 percent of the deaths from explosions during the past 8 years. During the past year 52.6 percent of the fatalities from explosions were of electrical origin, which was a little less than the average. The fact that electricity continues to lead the list of causes of explosions in mines is evidence of a certain amount of continuance of lack of respect for the hazard of electric arcs in the presence of gas and dust. The rapid increase in the introduction of electrical equipment underground during the past few years is likely to result in an increase in electrical explosions unless simultaneously with augmented use of electrical equipment in mines increased attention is given to precautionary measures in the use of such equipment.

Open lights or smoking caused explosions resulting in 205 deaths during the past 8 fiscal years and in 23.2 percent of all fatalities due to explosions during that period. During the past year 10 deaths, were so caused which accounted for 26.3 percent of all fatalities due to explosions. Five of the explosions caused by open lights during the year were in anthracite mines, and in 10 explosions caused by open lights no fatalities resulted. At least two explosions resulted when it is reported that men attempted to smoke in the presence of gas; this is decidedly reprehensible.

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involving as it does a flagrant disregard by the culprit of not only his own safety but also that of his fellow workers.

During the past 8 years 148 deaths (16.7 percent of all deaths due to explosions during this period) resulted from explosions caused by the misuse of explosives. A very marked reduction has been made during the past 3 years in explosion fatalities caused by blasting; only 9 deaths were so caused during the 3 years compared with a yearly average of 18.5 deaths during the past 8 years. Only one explosions, which resulted in 4 deaths, was charged to explosives during the past fiscal year; the exact cause of this explosion was not definitely determined, and although explosives were suspected of being the cause it is entirely possible that an arc from a mining machine may have been responsible.

During the past 8 years 35 persons have been killed in mines of the United States in 16 explosions, the causes of which were of miscellaneous character or could not be ascertained by the Bureau of Mines. During the past year two explosions, which resulted in four deaths, were classified as miscellaneous. It is often difficult, if not impossible, to determine definitely the cause of an explosion, because usually the persons involved in the origin are killed and surrounding conditions have been changed to such extent that available evidence does not reveal the cause.

ELECTRICAL CAUSES OF EXPLOSIONS

Table 5 gives a "break-down" of data relating to details of the causes of explosions of electrical origin in the United States during the past 8 fiscal years, insofar as data are available to the Bureau of Mines. During the period there were 88 ignitions of electrical origin, with 5 ignitions, causing 20 deaths, during the past fiscal year. The greatest sources of electrical ignitions in coal mines are trolley or cable-reel locomotives and nonpermissible mining machines; these two were responsible for approximately one-half of the electrical ignitions during the 8-year period.

During the past fiscal year a trolley locomotive, a nonpermissible mining machine, faulty wiring, a trolley wire, and an electric arc were responsible for the 5 electrical ignitions. In the ignition charged to faulty wiring lightning struck the power line to an underground motor-generator set, igniting gas and burning the set.

In most electrical ignitions that have occurred during the past 8 years there has been evidence of carelessness in ventilation, as where doors have been used on main or important haulage entries and left open or line brattices were in poor condition or not near enough to the face. Some other factors concerned in these electrical ignitions were: Failure to test for gas before going into working place with mining machine or electric drill; use of electrical equipment too soon after mine fan has been started after a period of shut-down; and use of haulageways as return airways, this latter cause being always hazardous in the extreme, especially where electricity is used, whether in gassy or so-called nongassy mines.

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TABLE 5. - Electrical causes of explosions, fiscal years 1929 to 1936, inclusive

Cause	Number of electrical ignitions by fiscal years								Total, 8	Number killed		Number injured	
	1929[1]	1930[2]	1931[3]	1932[4]	19335[5]	19346[6]	19357[7]	1936	Years	1935	1936	1935	1936
Trolley or cable-reel locomotive	[8]/5	5	1	1	4	5	3	1	[8]/24	1	2	4	-
Nonpermissible mining machine	[9]/5	5	3	3	1	-	2	1	[9]/19	4	1	4	1
Nonpermissible electric motor	4	3	-	-	-	-	2	-	9	2	-	-	-
Nonpermissible shot-firing battery or circuit	-	[10]/2	[10]/3	1	-	1	-	-	2	-	-	-	-
Cable nips or blow-outs	-	2	-	-	-	1	-	-	3	-	-	-	-
Nonpermissible electric drills	-	-	-	2	-	1	2	-	5	20	-	12	-
Nonpermissible storage battery locomotives	1	1	2	-	-	-	-	-	4	-	-	-	-
Nonpermissible electric hoists	-	-	-	-	1	-	-	-	1	-	-	-	-
Faulty wiring	2	2	-	-	-	-	-	1	5	-	-	-	-
Trolley wire	1	-	2	1	-	-	-	1	5	-	8	-	-
Electric arc	2	-	1	2	1	2	1	[11]/1	10	2	9	-	-
Signal wire	-	-	-	-	1	-	-	-	1	-	-	-	-
Total	18	18	9	10	8	10	10	5	88	29	20	20	1

1/ See Inf. Cir. 6178.
2/ See Inf. Cir. 6419.
3/ See Inf. Cir. 6540.
4/ See. Inf. Cir. 6680.
5/ See Inf. Cir. 6761.
6/ See Inf. Cir. 6819.
7/ See Inf. Cir. 6870.
8/ 1 not included in total; may have been from open light.
9/ 1 not included in total; may have been from smoking.
10/ Not included in total; may have been from overcharged shots.
11/ Included, but may have been from smoking.

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TABLE 6. - Comparison of lighting in mines where explosions occurred, fiscal years 1929 - 36, inclusive

Year	Open lights		Closed lights		Lighting unknown		Total	
	Number of explosions	Per-cent	Number of explosions	Per-cent	Number of explosions	Per-cent	Number of explosions	Per-cent
1929.....	18	47.4	19	50.0	1	2.6	38	100
1930.....	8	23.5	25	73.5	1	3.0	34	100
1931.....	12	44.4	15	55.6	-	-	1/27	100
1932.....	15	44.1	15	44.1	4	11.8	1/34	100
1933.....	7	31.8	14	63.6	1	4.6	22	100
1934.....	9	34.6	14	53.9	3	11.5	26	100
1935.....	6	26.1	17	73.9	-	-	23	100
1936.....	15	60.0	9	36.0	1	4.0	25	100
Total, 8 years	90	39.3	128	55.9	11	4.8	2/229	100

1/ 1 mine had mixed (open as well as closed) lighting.

2/ 2 mines had mixed (open as well as closed) lighting.

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COMPARISON OF LIGHTING IN MINES WHERE EXPLOSIONS OCCURRED

In a comparison of lighting practices in mines where explosions have occurred during the past 8 fiscal years, as shown in table 6, it is observed that of the 229 explosions listed 90 (39.3 percent of the total) were in open-light mines; that 128 (55.9 percent) were in closed-light mines; and that 11 (4.8 percent) were in mines in which the lighting practice was unknown. During the past fiscal year 15 (60 percent) of the explosions occurred in open-light mines, a considerable increase over the percentage for the preceding 7 years. It is difficult to explain the reason for this large increase in explosions in open-light mines in the face of the fact that during the past year a number of open-light coal mines changed to closed lights; very probably the increase is due partly to laxity in discipline plus the taking of unusual chances with open lights because of the relative immunity from accidents during the past several years. The fact that 55.9 percent of the explosions occurring during the 8-year period were in closed-light mines would appear to indicate a lack of appreciation of the hazards of inadequate ventilation, with attendant use of nonpermissible electrical equipment and nonpermissible explosives, or only a half-hearted attempt to control ignitions of gas or dust. There is good reason to believe that in many mines in which closed lights are adopted undue dependence is placed in the lamps and that ventilation and other precautionary measures are relaxed.

EXPLOSIONS IN BITUMINOUS-COAL MINES

The graph shows the fatalities resulting from gas and coal-dust explosions in bituminous-coal mines in the United States during the calendar years 1906 to 1935, inclusive. It is noted that the trend was downward from 1907 to 1921, with a marked rise from 1921 to 1924 and a definite, fairly steady, downward trend from that year to date. It is rather significant that every alternate year since 1924 has shown an increase in the number killed over the preceding year, although the general trend has been downward. No explanation can be given for this fact other than the possibility that a year with relatively low explosion fatality record probably causes a certain amount of relaxation of accident prevention effort during the following year, and, conversely, one or more explosion disasters tend to act as a spur toward the taking of precautionary measures; if the trend that has prevailed during the past 11 years is to continue we may expect a slight increase in the number killed by explosions in the calendar year 1936 over that for 1935.

The tabulation on the graph giving average yearly fatalities from bituminous-coal mine gas and dust explosions over 5-year periods from 1906-10 to 1931-35 is illuminating, showing, as it does, a heavy and fairly steady decrease in annual fatalities from 438 for the 5-year period 1906-10 to 65 for the 5-year period 1931-35, a decrease of 85.2 percent. The significance of this is seen from the fact that if the rate of explosion fatalities for the 5-year period 1906-10 (438 per year) had continued through 1935, 13,140 lives would have been lost from this cause instead of 7,800 (the approximate number actually lost); if the rate of occurrence of such accidents in the 5-year period 1931-35 (65 per year) had been in effect from 1906 to the end of 1935, the total would have been only 1,950 instead of the approximately 7,800 that actually were killed. These figures give a rather startling

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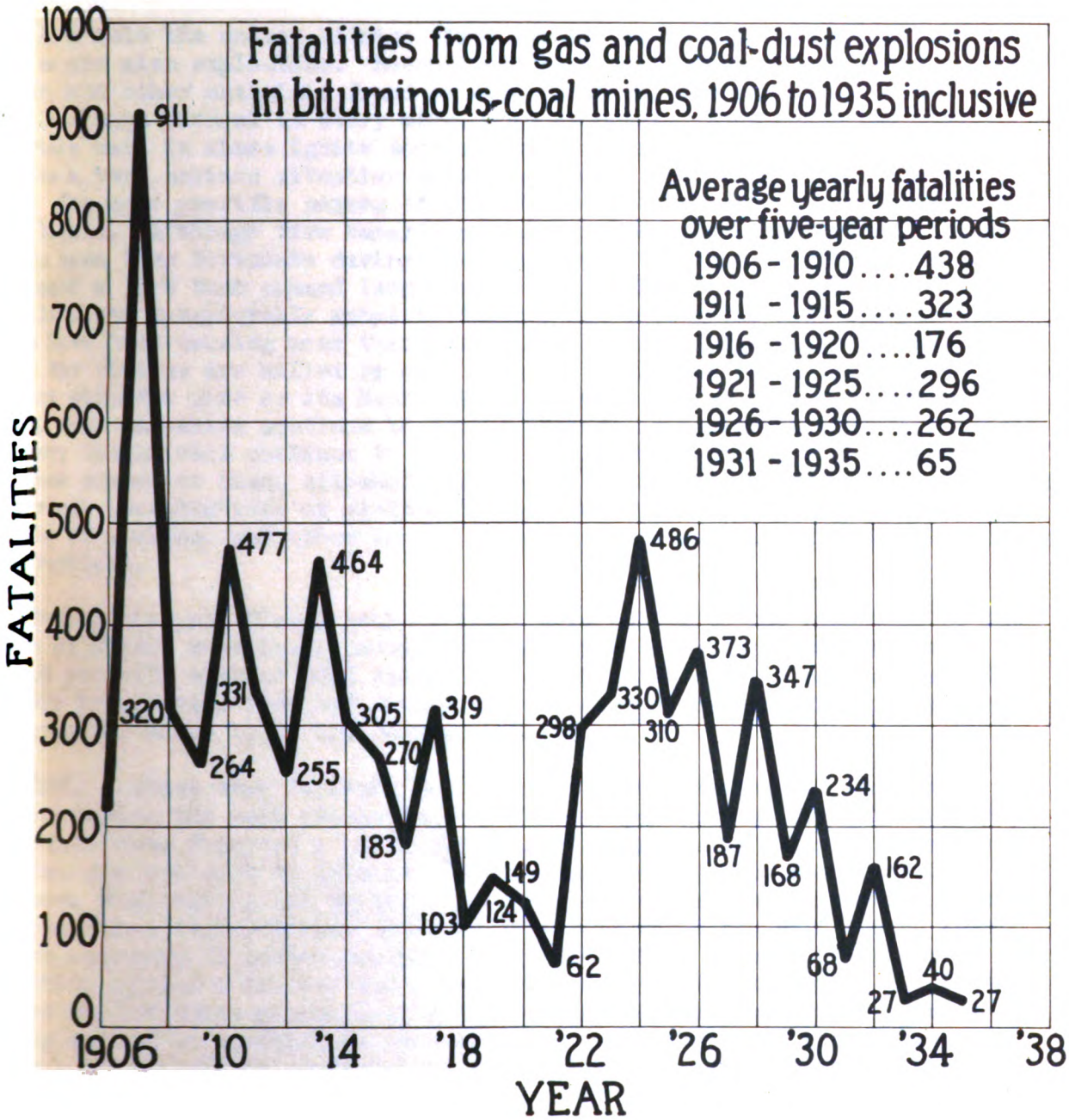

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picture of the progress that has been made in the reduction of coal-mine disasters in the United States since the U. S. Bureau of Mines was commissioned by Congress in 1910 to try to reduce the annual death toll from such mine disasters.

MINE FIRES

As a rule the causes of mine fires are not as readily subject to prevention as are mine explosions. Because of the highly combustible nature of coal, timber, and other materials found or used in mines, the potential hazard of a fire is always present in every mine, coal or metal. Some coals and other materials used in mines ignite spontaneously under certain conditions, which creates a very serious situation where such coals are being mined or materials used. The most prolific causes of mine fires are electricity, explosives, and open lights. Although fire hazards are always present, the mines of the United States have been fortunate during the past decade in that they have not experienced a fire that caused large loss of life; however, a number of fires have involved considerable property damage, and during the past few years mine fires have been causing more than usual loss of life, especially in coal mines, where the victims are killed by breathing the poisonous gases rather than by contact with the fire or its heat. Although much can be done to prevent mine fires, some companies continue to employ methods or equipment that have caused and very likely will continue to cause fires in their mines, such as the use of black powder or fuse; slipshod methods of installing, using, and maintaining electrical installations or equipment; continued use of open lights; the permitting of smoking; and other loose, unsafe, and out-of-date mining methods and practices.

During the past fiscal year 23 fires were called to the attention of the Bureau of Mines; doubtless, scores of other fires were detected and extinguished promptly without much damage or were handled quietly and more or less secretly by the mine involved, hence their occurrence was not made known to the Bureau of Mines or to the general public.

Table 7 shows that Colorado had the most fires reported to the Bureau of Mines during the past fiscal year, 4 fires were reported from that State. Three fires were reported in Kentucky; 2 each in Alabama, Illinois, Utah, and Virginia; and one each in Arizona, California, Idaho, Ohio, Pennsylvania, Tennessee, Washington, and Wyoming. Of these 23 fires 7 were in metal mines. Four fatalities resulted from these 23 fires, of which two were caused when men were overcome by carbon monoxide while attempting to seal off a fire. Electricity caused 7 of the fires, open lights two, and explosives 3. Of the 11 fires listed under miscellaneous causes 4 are of unknown origin, 3 were probably caused by spontaneous combustion, 1 was probably of incendiary origin, 1 was caused by an acetylene torch, 1 was an old fire that broke through a seal, and 1 was caused by ignition of oil and grease on a locomotive. The three fires charged to explosives were caused by flame from black powder shots igniting the coal. The total number of fires (23) called to the attention of the Bureau of Mines during the fiscal year 1936 about equals the average for the preceding 6 years; the deaths caused by fires during the past year were one-half the average for this period, but there has been a disquieting increase in deaths from mine fires in coal mines in 1934, 1935, and 1936, which indicates lack of appreciation by coal-mining people of the hazards (especially from poisonous or asphyxiating gases) likely to be encountered in connection with mine fires.

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TABLE 7. - Mine fires by States, - fiscal years 1936 and 1930 - 6, inclusive

State	Lighting used			Fatalities by ignition causes									
				Electricity		Open lights		Explosives		Miscellaneous		Total	
	Open	Closed	Unknown	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions	Deaths	Ignitions
Alabama	2	-	-	1	2	-	-	-	-	-	-	1	2
Arizona	1	-	-	-	-	-	-	-	-	-	1	-	1
California	1	-	-	-	-	-	-	-	-	-	1	-	1
Colorado	1	-	3	-	-	-	-	-	-	-	4	-	4
Idaho	1	-	-	-	1	-	-	-	-	-	-	-	1
Illinois	1	1	-	-	1	-	-	-	-	-	1	-	2
Kentucky	3	-	-	-	-	-	1	-	2	-	-	-	3
Ohio	1	-	-	-	-	-	1	-	-	-	-	-	1
Pennsylvania	-	1	-	-	-	-	-	-	-	1	1	1	1
Tennessee	1	-	-	-	-	-	-	-	1	-	-	-	1
Utah	2	-	-	-	1	-	-	-	-	-	1	-	2
Virginia	1	1	-	-	1	-	-	-	-	-	1	-	2
Washington	-	1	-	-	1	-	-	-	-	-	-	-	1
Wyoming	1	-	-	-	-	-	-	-	-	2	1	2	1
Total, 1936	16	4	3	1	7	-	2	-	3	3	11	4	1/ 23
Total, 1935 4/	7	5	14	11	11	-	1	-	-	-	2/ 14	11	3/ 26
Total, 1934 5/	10	5	3	-	4	-	-	5	5	1	9	6	18
Total, 1933 6/	12	6	9	-	7	-	-	-	2	2	18	2	27
Total, 1932 7/	8	5	8	1	8	-	-	-	3	-	10	1	21
Total, 1931 8/	12	7	5	-	7	5	3	-	5	18	9	23	24
Total, 1930 9/	7	8	9	2	9	3	6	-	3	-	6	5	24
Total, 7 years	72	40	51	15	53	8	12	5	21	24	77	52	163

1/ Includes 7 metal-mine fires.
2/ 4 of these fires were caused by spontaneous combustion.
3/ Includes 5 metal-mine fires and 4 outcrop fires.
4/ See Inf. Circ. 6870.
5/ See Inf. Circ. 6819.
6/ See Inf. Circ. 6761.
7/ See Inf. Circ. 6680.
8/ See Inf. Circ. 6540.
9/ See Inf. Circ. 6419.

Note: This tabulation includes data only on mine fires called to the attention of the Bureau of Mines Safety Division.

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It is interesting to note that of the 25 major coal-mine fire disasters, with a total of 566 fatalities, since 1900, only 4 with 29 deaths have occurred since 1921 (to date of writing, Sept. 1, 1936); that no major coal-mine fire disasters occurred in the United States from 1926 to 1933, inclusive; and that 1 occurred in March 1934 with 5 fatalities, 1 in May 1935 with 6 fatalities, and 1 in August 1936 with 9 fatalities. The occurrence of 3 major mine fire disasters in the calendar years 1934, 1935, and 1936, with a total of 20 deaths, appears to show that our mining people are relaxing in precautions taken in the handling of fires, especially in protecting workers from asphyxiating or poisonous gases from the fires.

SUMMARY

The downward trend in the frequency and severity of coal-mine explosions in the United States during the past 8 years has been encouraging and indicates that efforts to prevent explosions have been largely successful. Insofar as the number of deaths from mine explosions is concerned, the fiscal year 1936 made next to the best record in the history of coal mining, 1934 having the best record. The frequency of explosions has not decreased at the same rate as has the severity, so it is fortunate that more men are not killed; the decrease in severity of explosions appears to indicate that greater precautions are now being taken than in the past to prevent the spread of explosions, some of these precautions being rock-dusting and the use of water on cutter bars of mining machines, as well as the use of more efficient ventilation in holding gas accumulations to minimum quantity and thus decreasing their "kick."

The years 1918, 1920, 1921, 1931, 1933, 1934, and 1935 have the best records for major explosions and fires in the mines of the United States; in 1936 only two major disasters occurred, in which a total of 17 men were killed, and in 1935 there were two major explosions, which resulted in 30 deaths. The material decline in the frequency and severity of explosions during the past 5 years is believed to be due primarily to: (1) Increased activities of the various State mine inspection departments, especially in educational work, and demand for more rigid adherence to State laws and to safety practices far beyond the strict letter of the law; (2) growing realization of the economic waste of all accidents, including explosions, and more or less general acceptance by the mine operators of responsibility for accident occurrence; and (3) widespread dissemination of safety data by the United States Bureau of Mines and other safety organizations.

Some salient points brought out in the study of mine explosions and fires in the United States by the Safety Division of the Bureau of Mines for the year ended June 30, 1936, are:

1. Twenty-five explosions were studied, 15 in bituminous mines and 10 in anthracite mines, compared with 23 in 1935 and a yearly average of 28.8 in the previous 7 fiscal years.

2. Explosions took 38 lives in 1936 compared with 54 in 1935 and an annual average of 121 in the previous 7 years. The 10 explosions in anthracite mines resulted in 8 deaths, whereas the 15 explosions in bituminous mines resulted in 30 deaths.

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3. The two major explosions caused 17 deaths, while the 23 minor explosions caused 21 deaths; in 13 of these explosions no deaths occurred.

4. Fifteen explosions occurred in open-light mines compared with 6 in 1935 and a yearly average of 10.6 in the previous 7 fiscal years. Nine explosions were in closed-light mines compared with 17 in 1935 and a yearly average of 17 in the previous 7 fiscal years.

5. Five explosions, causing 20 deaths, were of electrical origin compared with 10 explosions and 29 deaths from this cause in the previous fiscal year. Explosions of electrical origin averaged 12, with 68 deaths, annually for the previous 7 fiscal years. In the past 5 fiscal years a decided improvement has been shown in the frequency and severity of explosions of electrical origin.

6. The two major explosions that occurred during the past fiscal year were of electrical origin.

7. Open lights and smoking caused 17 explosions and 10 deaths in 1936 compared with 9 explosions and 6 deaths in 1935 and averages of 10.1 explosions and 27.9 deaths during the previous 7 fiscal years. Of these explosions 8 were in anthracite mines, and at least 3 were caused by miners in attempting to smok

8. One explosion, which caused 4 deaths, was attributed to the misuse of explosives during the past year compared with 2 explosions and 3 deaths from this cause in 1935 and an average of 5 explosions and 20.6 deaths during the previous 7 fiscal years. There is some question as to the cause of the one explosion charged to explosives during 1936; it was not definitely established that explosives were responsible, and it is possible that electricity may have been the ignition cause. In the past 8 fiscal years both the frequency and severity of explosions caused by explosives have declined gradually.

9. Rock dust was used to some extent in at least 4 mines in which explosions occurred during the past year; in 2 of these mines rock dust is credited with stopping the spread of the explosion.

10. All of the explosions during the past year are thought to have been initiated by gas.

11. The underlying cause of all explosions that occurred during 1936 was defective ventilation, which was manifest both in mines that used open lights and those that used closed lights.

12. The severity of explosions last year was reduced approximately 64 percent compared to the average for the preceding 7 years. The average number of deaths per explosion was 1.5 compared with an average of 4.2 deaths per explosion for the preceding 7 years.

13. The 38 deaths caused by explosions during the fiscal year 1936 occurre in 6 States; 21 of the coal-producing States had no fatalities from this cause

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14. During the fiscal year 1936, 23 mine fires (including 7 metal-mine fires) with 4 deaths were reported compared with an average of 23 fires and 8 deaths for the preceding 5 years.

CONCLUSIONS

This circular was compiled in the same manner as in previous years (see Information Circulars 6178, 6419, 6540, 6680, 6761, 6819, and 6870) and embodies only facts revealed through studies by field employees of the Safety Division of the United States Bureau of Mines. Although the Bureau of Mines attempts to obtain information on every explosion that occurs in the United States, some of the less destructive may not be brought to its attention early enough to permit investigation. However, the Bureau rarely fails to acquire fairly complete details of mine explosions in which more than one life is lost or in which a considerable amount of property is damaged; therefore the data in these publications are relatively complete, especially on explosions causing loss of more than one life. The data on mine fires are by no means as complete as those on explosions, and there is reason to believe that scores of fires in both coal and metal mines occur annually without the knowledge of the Bureau of Mines or even the State inspection forces. Mine fires occur almost daily in some coal mines, particularly at shot-firing time or where the coal fires spontaneously, and fires of electrical origin or those caused by open lights are not unusual in metal mines.

Study of data available on mine explosions in the United States during the past 8 years reveals an encouraging reduction in the frequency and severity of these disasters.

In the 20-year period preceding 1929, mine explosions and fire took an average toll of about 285 lives annually in the United States; since then the number of fatalities from explosions and fires has been reduced to an annual average of 114. The fiscal year 1934 established an all-time low record; only 34 fatalities resulted from explosions and fires compared with 42 fatalities from these causes during the fiscal year 1936. An analysis of the record for the fiscal years 1934, 1935, and 1936 demonstrates that explosions and fires can be largely if not wholly prevented and that loss of life from them can be greatly reduced; therefore the mining industry should not be satisfied until explosions and fires have been eliminated.

The reduction of fatalities due to gas and dust explosions in bituminous-coal mines from an average of 438 per year in the 5-year period 1906-10 to 65 per year in the 5-year period 1931-35, a decrease of 85.2 percent or an average decrease of about 2.8 percent per year, shows what can be done. There is absolutely no reason why the above trend should not continue, with practically the ultimate elimination of this type of mine accident in bituminous mines within another 5 years; moreover, what the bituminous industry accomplishes in prevention of gas and dust explosions should be accomplished as readily in all types of mines, including anthracite properties.

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